

FORM PTO-1390 (4/05/00)  
(REV 11/98)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

**TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371**

**R.34720**

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 1.5)

**09/674771**

INTERNATIONAL APPLICATION NO.

**PCT/DE 00/00511**

INTERNATIONAL FILING DATE

**24 February 2000**

PRIORITY DATE CLAIMED

**04 March 1999**

TITLE OF INVENTION

**PIEZOELECTRIC ACTUATOR**

APPLICANT(S) FOR DO/EO/US

**HEINZ, Rudolf****BOECKING, Friedrich**

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
  - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210)
8. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☐ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409)
12. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

**Items 13 to 20 below concern document(s) or information included:**

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ Certificate of Mailing by Express Mail
20. ☒ Other items or information:

Transmittal Sheets in duplicate w/fees charged to Dep. Acct. 07-2100  
 Copy of German Text Application w/2 sheets drawings  
 Translation of German Text Application w/2 sheets drawings  
 Executed Declaration (not enclosed)  
 Assignment to Robert Bosch GmbH (not enclosed)  
 Preliminary Amendment  
 Copy of PCT/RO/101, PCT/ISA/210 and 220

09/ 674771

PCT/DE 00/00511

R.34720

21. The following fees are submitted:

**BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):**

- ☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ..... **\$1,000.00**
- ☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... **\$860.00**
- ☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... **\$710.00**
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) ..... **\$690.00**
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) ..... **\$100.00**

**ENTER APPROPRIATE BASIC FEE AMOUNT =****\$860.00**Surcharge of **\$130.00** for furnishing the oath or declaration later than months from the earliest claimed priority date (37 CFR 1.492 (e)).☒ 20 ☐ 30**\$130.00**

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	21 - 20 =	1	x \$18.00	<b>\$18.00</b>
Independent claims	- 3 =	0	x \$80.00	<b>\$0.00</b>
Multiple Dependent Claims (check if applicable)			<input type="checkbox"/>	<b>\$0.00</b>

**TOTAL OF ABOVE CALCULATIONS =****\$1,008.00**

Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable).

☐**\$0.00****SUBTOTAL =****\$1,008.00**Processing fee of **\$130.00** for furnishing the English translation later than months from the earliest claimed priority date (37 CFR 1.492 (f)).☐ 20 ☐ 30 +**\$0.00****TOTAL NATIONAL FEE =****\$1,008.00**

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable).

☐**\$0.00****TOTAL FEES ENCLOSED =****\$1,008.00**

Amount to be:	\$
refunded	
charged	\$

- ☐ A check in the amount of \_\_\_\_\_ to cover the above fees is enclosed.
- ☒ Please charge my Deposit Account No. **07-2100** in the amount of **\$1,008.00** to cover the above fees.  
A duplicate copy of this sheet is enclosed.
- ☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **07-2100** A duplicate copy of this sheet is enclosed.

**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive 37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**SEND ALL CORRESPONDENCE TO:**

Ronald E. Greigg  
**GREIGG & GREIGG P.L.L.C.**  
 1423 Powhatan Street, Unit One  
 Alexandria, Virginia 22314

Telephone: (703) 838-5500  
 Facsimile: (703) 838-5554

SIGNATURE

Ronald E. Greigg

NAME

31,517

REGISTRATION NUMBER

06 November 2000

DATE

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Rudolf Heinz et al

Based on PCT/DE 00/00511

For: Piezoelectric Actuator

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents  
Washington, D.C. 20231

Sir:

Prior to examination, please amend the above-identified application as follows:

Page 1, between the title and first line of the specification, insert the following:

--Cross-References to Related Applications

This is a 35 USC 371 application of PCT/DE 00/00511 filed on February 24, 2000.--

line 2, delete "Prior Art" and insert --Background of the Invention--;

between lines 2 and 3, insert --Field of the Invention--;

line 3, delete "The" and insert --This-- and delete "actuator, in" and insert --actuators, and more--;

line 4, delete "particular for actuating" and insert --particularly to such actuators for--;

line 5, before "having" insert --and--;

between lines 13 and 14, insert --Description of the Prior Art--.

Page 2, line 10, delete "Objects and Advantages" and insert --Summary--;

line 12, after "actuator" delete comma.

Page 3, delete line 1;

line 2, before "object" insert --above--;

line 10, delete "according to" and insert --of--;

line 21, delete "hardly" and insert --little--.

Page 4, between lines 2 and 3, insert --Brief Description of the Drawings--;

line 4, after "below," insert --taken--;

delete line 5;

line 6, delete "invention" and after "drawings" delete period and insert --, in which:--;

line 7, delete "Drawings."

Page 5, line 1, delete "Exemplary Embodiments" and insert --Description of the Preferred Embodiments--;

line 8, delete "bore" and insert --body--.

Page 7, line 7, delete "according to" and insert --of--;

line 10, delete "circumference" and insert --circumferential--;

line 12, delete "circumference" and insert --circumferential--;

line 15, after "180°" delete "C";

line 16, delete "on" and insert --around-- and delete "circumference" and insert --circumferential--;

line 18, delete "circumference" and insert --circumferential--.

Page 10, after line 6, insert the following paragraph:

--The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.--.

IN THE CLAIMS

Page 11, line 1, delete "Claims" and insert --We Claim--.

Please cancel claims 1-10 and add new claims 11-31.

11. In a piezoelectric actuator of the type used for actuating control valves or injection valves of internal combustion engines in motor vehicles, the actuator having a circular, cylindrical piezoelectric actuator body (1) in the form of a multilayered laminate made up of stacked layers of piezoelectric material with intervening metallic or electrically conductive, alternating first and second electrode layers (10, 11) that function as electrodes, wherein these first and second electrode layers (10, 11) alternately contact a first and second electrically conductive common electrode connection (12, 13), the improvement wherein the actuator body (1) has an internal longitudinal bore (2) and at least the first common electrode connection (12) is provided on the inner wall (3) of the actuator body (1) constituted by the internal longitudinal bore (2) and contacts every first electrode layer (10) there.

12. The piezoelectric actuator according to claim 11, wherein the second common electrode connection (13) is provided on the outer wall (4) of the actuator body (1) and contacts every second electrode layer (11) there.

13. The piezoelectric actuator according to claim 11, wherein the second common electrode connection (13) is also provided on the inner wall (3) of the actuator body (1) and contacts every second electrode layer (11) there.

14. The piezoelectric actuator according to claim 13, wherein the first and second electrode connections (12, 13) constitute narrow electrode strips that are disposed diametrically opposite each other and extend in the longitudinal direction of the actuator body (1).

15. A piezoelectric actuator for actuating control valves or injection valves of internal combustion engines in motor vehicles, comprising a circular, cylindrical piezoelectric actuator body (1) in the form of a multilayered laminate made up of stacked layers of piezoelectric material with intervening metallic or electrically conductive, alternating first and second electrode layers (10, 11) that function as electrodes, wherein these first and second electrode layers (10, 11) alternately contact a first and second electrically conductive common electrode connection (12, 13), said first and second electrode layers (10, 11) are respectively disposed on the outer cylinder wall (4) of the actuator body (1) at points that are angularly offset from one another and contact the first and second electrode connections (12, 13) there.

16. The piezoelectric actuator according to claim 15, wherein the points of the first and second electrode layers and the first and second electrode connections (12, 13)

in contact with them, which are exposed on the outer cylinder wall (4) of the actuator body (1), are disposed diametrically opposite one another.

17. The piezoelectric actuator according to claim 15, wherein each first electrode layer (10) has a recess (17) which encompasses and insulates the second electrode connection (13).

18. The piezoelectric actuator according to claim 15, wherein each second electrode layer (11) has a recess (18) which encompasses and insulates the first electrode connection (12).

19. The piezoelectric actuator according to claim 15, wherein the first and/or second electrode connection (12, 13) constitutes a narrow strip extending in the longitudinal direction of the actuator body.

20. The piezoelectric actuator according to claim 15, wherein the first and/or second electrode connection (12, 13) constitutes a wider contact surface in the form of a section of the cylinder circumference extending in the longitudinal direction of the actuator body (1).

21. The piezoelectric actuator according to claim 16, wherein each first electrode layer (10) has a recess (17) which encompasses and insulates the second electrode connection (13).

22. The piezoelectric actuator according to claim 16, wherein each second electrode layer (11) has a recess (18) which encompasses and insulates the first electrode connection (12).

23. The piezoelectric actuator according to claim 17, wherein each second electrode layer (11) has a recess (18) which encompasses and insulates the first electrode connection (12).

24. The piezoelectric actuator according to claim 16, wherein the first and/or second electrode connection (12, 13) constitutes a narrow strip extending in the longitudinal direction of the actuator body.

25. The piezoelectric actuator according to claim 17, wherein the first and/or second electrode connection (12, 13) constitutes a narrow strip extending in the longitudinal direction of the actuator body.

26. The piezoelectric actuator according to claim 18, wherein the first and/or second electrode connection (12, 13) constitutes a narrow strip extending in the longitudinal direction of the actuator body.

27. The piezoelectric actuator according to claim 16, wherein the first and/or second electrode connection (12, 13) constitutes a wider contact surface in the form of a



section of the cylinder circumference extending in the longitudinal direction of the actuator body (1).

28. The piezoelectric actuator according to claim 16, wherein the first and/or second electrode connection (12, 13) constitutes a wider contact surface in the form of a section of the cylinder circumference extending in the longitudinal direction of the actuator body (1).

29. The piezoelectric actuator according to claim 17, wherein the first and/or second electrode connection (12, 13) constitutes a wider contact surface in the form of a section of the cylinder circumference extending in the longitudinal direction of the actuator body (1).

30. The piezoelectric actuator according to claim 18, wherein the first and/or second electrode connection (12, 13) constitutes a wider contact surface in the form of a section of the cylinder circumference extending in the longitudinal direction of the actuator body (1).

31. The piezoelectric actuator according to claim 19, wherein the first and/or second electrode connection (12, 13) constitutes a wider contact surface in the form of a section of the cylinder circumference extending in the longitudinal direction of the actuator body (1).

IN THE ABSTRACT

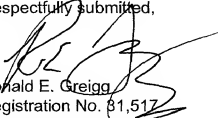
Please substitute the attached Abstract for the original abstract as filed.

REMARKS

The above amendments are being made to place the application in better condition for examination.

Entry of the amendment is respectfully solicited.

Respectfully submitted,

  
Ronald E. Greigg  
Registration No. 81,517  
Attorney for Applicant

Greigg & Greigg P.L.L.C.  
1423 Powhatan Street, Unit One  
Alexandria, Virginia 22314  
Telephone: (703) 838-5500  
Facsimile: (703) 838-5554

## Abstract

The invention relates to a piezoelectric actuator, in particular for actuating control valves or injection valves of internal combustion engines in motor vehicles, having a circular, cylindrical piezoelectric actuator body in the form of a multilayered laminate made up of stacked layers of piezoelectric material with intervening metallic or electrically conductive, alternating first and second electrode layers that function as electrodes, wherein these first and second electrode layers alternately contact a first and second electrically conductive common electrode connection. Either the piezoelectric actuator body has either an internal longitudinal bore and at least the first common electrode connection is provided on the inner wall of the actuator body constituted by the internal longitudinal bore and contacts every first electrode layer there or alternatively, the actuator body has no internal bore and the first and second electrode layers are respectively exposed on the outer cylinder wall of the actuator body at points angularly offset from one another and respectively contact the first and second electrode connections there.

2/PRTS

# Piezoelectric Actuator

## Prior Art

The invention relates to a piezoelectric actuator, in particular for actuating control valves or injection valves of internal combustion engines in motor vehicles, having a circular, cylindrical piezoelectric actuator body in the form of a multilayered laminate made up of stacked layers of piezoelectric material with intervening metallic or electrically conductive, alternating first and second electrode layers that function as electrodes, wherein these first and second electrode layers alternately contact a first and second electrically conductive common electrode connection.

Generally, high-voltage piezoelectric actuators that are cylindrical in shape are known which, as individual disks with fixed electrodes, are stacked into a cylinder (e.g. see US patent 4 460 842). For the external electrode connections, electrode plates are routed to the circumference of the cylindrical stack and are bent at right angles there so that strip-shaped electrode connections that are angularly offset from one another can contact the respective electrodes that are associated with one another.

For the use of a piezoelectric actuator for actuating injection valves in internal combustion engines of motor

vehicles, a cylindrical actuator is advantageous since it optimally utilizes the available installation space in an injector body and in a circular bore in the cylinder head of the engine. Then a high-pressure bore can also be routed in the injector body or housing next to the actuator.

The circular contour of the actuator body requires a special electrode structure in order to be able to embody an electrically and mechanically favorable contacting of the electrodes with associated electrode connections.

## Object and Advantages of the Invention

In accordance with the above, the object of the invention is to produce a piezoelectric actuator, that is particularly suited for actuating control valves or injection valves of internal combustion engines in motor vehicles, having a circular, cylindrical piezoelectric actuator body in the form of a multilayered laminate made up of stacked layers of piezoelectric material with intervening metallic or electrically conductive, alternating first and second electrode layers that function as electrodes, so that a mechanically stable, space-saving, and electrically reliable contacting of the electrode layers with the associated electrode connections is possible.

This object is attained according to the application.

The attainment of the object can be made up of two aspects according to the invention:

- In the first aspect according to the invention, the  
5 circular, cylindrical actuator body has an internal bore,  
wherein the first electrode connections are disposed on the  
inside and the second electrode connections are affixed  
externally or also, both electrode connections are  
accommodated in the internal bore.

10 - According to the second aspect according to the  
invention, the actuator body is likewise circular and  
cylindrical, but does not have an internal bore. The electrode  
connections are disposed on the circumference of the  
cylindrical actuator body and are angularly offset in relation  
15 to one another, wherein the first and second electrode layers  
also have respective recesses which insulatingly encompass the  
electrode connection that is not in contact with this  
electrode layer.

20 In this manner, an advantageous piezoelectric actuator  
can be produced, whose outer contour - despite the electrode  
connections - diverges hardly or not at all from the circular,  
cylindrical form so that a piezoelectric actuator of this kind  
can be snugly fitted into a circular, cylindrical bore of an

injector body, wherein there is still space for a high-pressure bore in the wall of the injector body.

The above-mentioned features of the invention and others will be discussed in more detail in the description below, which describes various exemplary embodiments according to the invention in conjunction with the drawings.

Drawings.

Figs. 1A & 1B respectively show perspective and longitudinal sectional views of a piezoelectric actuator embodied according to the first aspect of the invention.

Figs. 2A & 2B respectively show perspective and longitudinal sectional views of a variant of a piezoelectric actuator according to the invention embodied in accordance with the first aspect.

Figs. 3A & 3B respectively show perspective and longitudinal sectional views of a piezoelectric actuator embodied in accordance with the second aspect according to the invention.

Figs. 4 to 8 show cross sections of variants of the exemplary embodiment of a piezoelectric actuator depicted in Figs. 3A and 3B.

## Exemplary Embodiments

Fig. 1A shows a circular, cylindrical actuator body 1, which is provided with a central, internal longitudinal bore 2.

According to Fig. 1B, first electrode layers 10, which alternate with second electrode layers 11 in the piezoelectric actuator body 1, are exposed on the inner wall 3 of the actuator bore 1 that is constituted by the central, internal longitudinal bore 2 and contact a first common electrode connection 12 there, while the second electrically conductive electrode layers 11 are exposed on the outer cylinder wall 4 of the actuator body 1 and contact a second common electrode connection 13 there. In this manner, the first common electrode connection 12 is disposed on the inside and second common electrode connection 13 is disposed on the outside of the actuator body 1. In the cross section through the actuator body 1 shown in Fig. 1B, it is also clear that the first electrode layers 10 that contact the first electrode connection 12 do not extend to the outer cylinder wall 4 and that the second electrode layers 11 that contact the second common electrode connection 13 do not reach the inner wall 3 of the actuator body 1 constituted by the bore 2.

In principle, the first common electrode connection 12 covers the entire inner wall 3 of the actuator body 1 in a circular fashion and the second common electrode connection 13



covers the entire outer wall 4 in a circular fashion.  
Alternatively, the first and second electrode connection 12 and 13 can also be routed only in the form of a strip parallel to the longitudinal axis of the actuator body 1.

5           The variant of the piezoelectric actuator embodied in accordance with the first aspect according to the invention shown in Figs. 2A and 2B differs from the first embodiment shown in Figs. 1A and 1B in that none of the first and second electrode layers 10 and 11 are exposed on the outer cylinder wall 4 of the actuator body 1, but instead contact the first and second common electrode connection 12 and 13 exclusively on the inner wall 3 that is constituted by the internal longitudinal bore 2.

10           The first and second common electrode connections 12 and 15   13 constitute narrow contact strips which are disposed on the inner wall 3 of the actuator body 1 and are aligned in its longitudinal direction.

          The advantage of the exemplary embodiment of the piezoelectric actuator according to the invention shown in 20   Figs. 2A and 2B lies in the high degree of utilization of the active piezoelectric surfaces.

          In contrast, the advantage of the exemplary embodiment of a piezoelectric actuator according to the invention shown in Figs. 1A and 1B is that a prestressing element, e.g. in the

form of a metallic pin, can be inserted through the internal bore 2 in order to exert a mechanical initial stress on the two end faces of the actuator body 1. As a result, tension brackets that are guided along the outside of the actuator body 1 can be eliminated.

A piezoelectric actuator embodied in accordance with the second aspect according to the invention, as shown in Figs. 3A and 3B, has no internal bore. The alternating first and second electrode layers 10 and 11 are respectively exposed on opposite circumference sides of the circular, cylindrical actuator body 1 and contact the first and second electrode connections 12, 13 on these opposite circumference sides. The perspective depiction in Fig. 3A shows that the contact surfaces available for the first and second electrode connections 12, 13 can, in principle, extend to almost 180° on the circumference surface of the cylinder. The first and second electrode connections 12, 13 then each constitute a shell on the cylinder circumference surface. So that the first and second electrode connections 12, 13 are insulated from one another, two diametrically opposed strips remain untouched by electrode connections.

The sectional view depicted in Figs. 4A and 4B shows one such variant with wide contact surfaces for the first and second common electrode connections 12 and 13. According to Fig. 4B, each first electrode layer 10 is recessed around the shell-shaped second electrode connection 13, wherein this

recess 17 is comprised of ceramic without electrode material. In precisely same manner, every second electrode layer 11 is recessed around the first common electrode connection 12 so that the first electrode layer 12 is insulated in relation to the second electrode layer 11. This recess 18 is also comprised of ceramic without electrode material. According to Figs. 4A and 4B, the form of the recesses 17 and 18 is arc-shaped, wherein the arc of the first and second recesses encloses a slightly greater angular range than the shell of the second and first electrode connections.

In principle, the electrode surface area of a piezoelectric actuator is better utilized the smaller the contact surfaces of the first and second common electrode connections become. One embodiment for this is shown in Figs. 5A, 5B, 6, and 7. The first and second electrode connections 12 and 13 constitute narrow, diametrically opposed contact strips which are aligned in the longitudinal direction on the outer circumference 4 of the piezoelectric actuator body 1. The respective recesses 17 and 18 can therefore be small so that they take only small parts of the surface area away from the respective electrode surfaces of the first and second electrode layers 10 and 11.

In contrast to Figs. 4 and 5, the variants according to Figs. 6 to 8 show only a side view, wherein only one of the electrode layers, e.g. one of the first electrode layers 10 and the recess 17 encompassing the contact strip of the second

electrode connection 13, can be seen. According to Figs. 6 and 7, the recesses 17 are limited to small parts of the service area of the first electrode layers 10. The recesses 18 (not shown) are then formed in precisely same manner around the contact strip constituting the first common electrode connection 12.

According to Fig. 6, the recesses 17 and 18 have the form of a segment of a circle. According to Fig. 7, the recesses 17 and 18 have the form of an arc-shaped section respectively cut from the first and second electrode layer.

In contrast to those in Figs. 5 to 7, the first and second common electrode connections 12 and 13 in Fig. 8 are embodied similarly to those in Fig. 4, in the form of wide shells and each recess 17 of the first electrode layer is disposed approximately in the form of a crescent around the second electrode layer 13. The second recess 18 of the second electrode layers 11 (not shown in Fig. 8) then has the same form around the first electrode connection 12.

Particular to all of the exemplary embodiments shown in Fig. 3 to 8 is an offset disposition of the first and second electrode layers 10 and 11 according to Fig. 3B, wherein the first and second electrode layers 10 and 11 are each exposed on diametrically opposite sides of the cylinder circumference surface and maintain contact there with narrow contact strips of the first and second common electrode connections 12, 13

(see Figs. 5, 6, and 7) or with wider contact shells of the first and second common electrode connections 12 and 13 (Figs. 4 and 8). The outer contours of the exemplary embodiments of a piezoelectric actuator according to the invention shown in the Figs. diverge hardly or not all from the circular, cylindrical form that is optimal for the intended use indicated.

## Claims

1. A piezoelectric actuator, in particular for actuating control valves or injection valves of internal combustion engines in motor vehicles, having a circular, cylindrical piezoelectric actuator body (1) in the form of a multilayered laminate made up of stacked layers of piezoelectric material with intervening metallic or electrically conductive, alternating first and second electrode layers (10, 11) that function as electrodes, wherein these first and second electrode layers (10, 11) alternately contact a first and second electrically conductive common electrode connection (12, 13), characterized in that the actuator body (1) has an internal longitudinal bore (2) and that at least the first common electrode connection (12) is provided on the inner wall (3) of the actuator body (1) constituted by the internal longitudinal bore (2) and contacts every first electrode layer (10) there.

2. The piezoelectric actuator according to claim 1, characterized in that the second common electrode connection (13) is provided on the outer wall (4) of the actuator body (1) and contacts every second electrode layer (11) there.

3. The piezoelectric actuator according to claim 1, characterized in that the second common electrode connection (13) is also provided on the inner wall (3) of the actuator body (1) and contacts every second electrode layer (11) there.

4. The piezoelectric actuator according to claim 3, characterized in that the first and second electrode connections (12, 13) constitute narrow electrode strips that are disposed diametrically opposite each other and extend in the longitudinal direction of the actuator body (1).

5. A piezoelectric actuator, in particular for actuating control valves or injection valves of internal combustion engines in motor vehicles, having a circular, cylindrical piezoelectric actuator body (1) in the form of a multilayered laminate made up of stacked layers of piezoelectric material with intervening metallic or electrically conductive, alternating first and second electrode layers (10, 11) that function as electrodes, wherein these first and second electrode layers (10, 11) alternately contact a first and second electrically conductive common electrode connection (12, 13), characterized in that the first and second electrode layers (10, 11) are respectively disposed on the outer cylinder wall (4) of the actuator body (1) at points that are angularly offset from one another and contact the first and second electrode connections (12, 13) there.

6. The piezoelectric actuator according to claim 5, characterized in that the points of the first and second electrode layers and the first and second electrode connections (12, 13) in contact with them, which are exposed on the outer cylinder wall (4) of the actuator body (1), are disposed diametrically opposite one another.

7. The piezoelectric actuator according to claim 5 or 6, characterized in that each first electrode layer (10) has a recess (17) which encompasses and insulates the second electrode connection (13).

8. The piezoelectric actuator according to one of claims 5 to 7, characterized in that each second electrode layer (11) has a recess (18) which encompasses and insulates the first electrode connection (12).

9. The piezoelectric actuator according to one of claims 5 to 8, characterized in that the first and/or second electrode connection (12, 13) constitutes a narrow strip extending in the longitudinal direction of the actuator body.

10. The piezoelectric actuator according to one of claims 5 to 8, characterized in that the first and/or second electrode connection (12, 13) constitutes a wider contact surface in the form of a section of the cylinder circumference extending in the longitudinal direction of the actuator body (1).



## Abstract

The invention relates to a piezoelectric actuator, in particular for actuating control valves or injection valves of internal combustion engines in motor vehicles, having a circular, cylindrical piezoelectric actuator body (1) in the form of a multilayered laminate made up of stacked layers of piezoelectric material with intervening metallic or electrically conductive, alternating first and second electrode layers (10, 11) that function as electrodes, wherein these first and second electrode layers (10, 11) alternately contact a first and second electrically conductive common electrode connection (12, 13). Either the piezoelectric actuator body (1) has either an internal longitudinal bore (2) and at least the first common electrode connection (12) is provided on the inner wall (3) of the actuator body (1) constituted by the internal longitudinal bore (2) and contacts every first electrode layer (10) there or alternatively, the actuator body (1) has no internal bore and the first and second electrode layers (10, 11) are respectively exposed on the outer cylinder wall (4) of the actuator body (1) at points angularly offset from one another and respectively contact the first and second electrode connections (12, 13) there. (Fig. 1B)

1/2

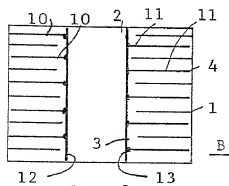
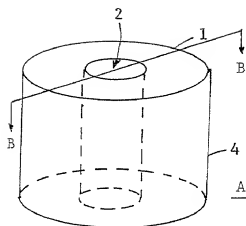


Fig. 2

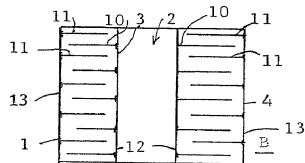
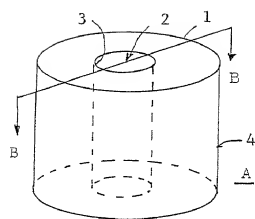


Fig. 1

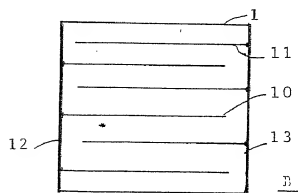
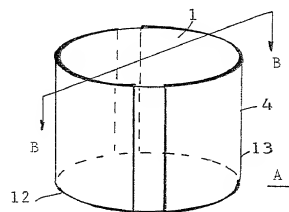
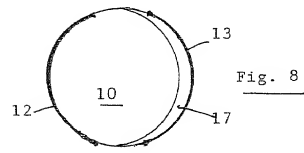
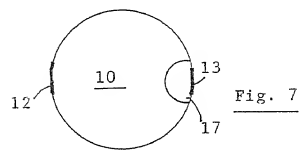
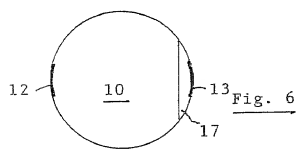
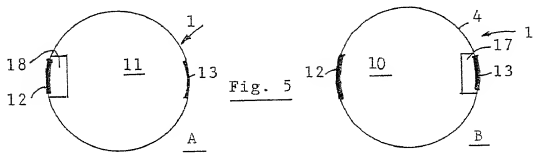
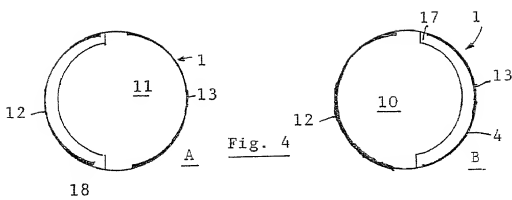


Fig. 3



Docket No.  
R.34720

# Declaration and Power of Attorney For Patent Application

## English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

PIEZOELECTRIC ACTUATOR

the specification of which

(check one)

☐ is attached hereto.

☒ was filed on 24 FEBRUARY 2000 as United States Application No. or PCT International Application Number PCT/DE 00/00511 and was amended on \_\_\_\_\_

(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Not Claimed

1 99 09 482.9

GERMANY

04 MARCH 1999

☒

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

☐

(Number)

(Country)

(Day/Month/Year Filed)

I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional application(s) listed below:

_____	_____
(Application Serial No.)	(Filing Date)
_____	_____
(Application Serial No.)	(Filing Date)
_____	_____
(Application Serial No.)	(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, C. F. R., Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

_____	_____	_____
(Application Serial No.)	(Filing Date)	(Status)
		(patented, pending, abandoned)
_____	_____	_____
(Application Serial No.)	(Filing Date)	(Status)
		(patented, pending, abandoned)
_____	_____	_____
(Application Serial No.)	(Filing Date)	(Status)
		(patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.